XI. *On the Pupal suspension of* Thais.

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Plate XII.

It is now some ten years since I ventured to question the view quoted in Scudder's great work on the American Butterflies as to the suspension of the pupa of *Thais* (Ent. Record, Vol. VI, pp. 125, 126), and somewhat later I obtained (Ent. Record, Vol. VII, pp. 81, 82) tolerably strong evidence that my opinion on the subject was correct. Up till the present time, however, no one has chosen to report actual observation of how the larva and pupa of *Thais* actually manage to make the girth (incidentally proving that it *is* the girth) leave its usual situation and become attached to the nose-hooks. This Spring (1904) I made an effort to supply the deficiency, and obtained a number of larvæ of *Thais polyxena*, Schiff., var. *cassandra*, Mann, from Hyères. I was successful in observing the whole operation by one specimen or another; whether I can successfully describe what I saw is I fear doubtful, but I will make the attempt. I was so interested in the matter, even someway outside the chief point in question, that I also made a successful attempt to see *Papilio machaon* and *Pieris rapæ* (as examples of *Papilionidæ* and *Pieridæ* respectively) make their silken holdfasts for their pupæ. Though there is no novelty about my observations of these, there are one or two points that may bear description again.

The first spinning done by the larva of *Thais* is to form what we must call a cocoon, though it consists merely of three or four, or at most a dozen, rather strong silken cables, sometimes simple, sometimes branching, tying together the objects surrounding the position chosen for suspension. This structure must be correlative with a habit of retiring for pupation into a situation surrounded by not very fixed materials, such probably as dead herbaceous material round shorter stems near the ground-level or below it. Having prepared a carpet of silk of rather more

than its own length, either on a flat surface or by preference on a round one such as a stem, it makes the anal pad. It may be noted here that in *Thais* and the other girthed pupæ observed, when this is completed the larva takes its station with the claspers just in front of it, the little mound of silk forming the pad being unused, and lying immediately behind the claspers and beneath the tip of the anal plate. In suspended pupæ this pad is held by the claspers, whilst the larva awaits pupation.

Before describing the spinning of the girth, it may be as well to explain its position on the larva when it is finished and the larva rests before pupating.

The girth arises well forwards from the carpet of silk, and passes over the back of the first abdominal segment. Each segment of the larva has on either side three tall processes or warts, which with their colours and spines give the larva its special and beautiful aspect. These three warts are a subdorsal one (= I. + II.?), which is the largest, then a somewhat smaller one (= IV. + V.?), which arises below the spiracle though one is inclined before examining it to think it is subdorsal also, *i. e.* above spiracle. The third one is still smaller, and is marginal (= VI.?). In passing over the segment, the girth reaches backwards from its attachment, to behind the marginal process, and passes up in the same line behind the subspiracular one; then it turns forward, and gets in front of the subdorsal process crossing the dorsum therefore rather on the front of the segment, proceeding down the other side of the larva, by, of course, a precisely similar route, to its attachment to the carpet on the other side. In taking this course it makes several bends. First it inclines rather backward from its attachment, has a bend at the marginal process where it turns upwards, and two more bends in passing from behind the subspiracular to the front of the subdorsal process. It is fairly taut, so much so as rather to bend forward the marginal process, against the similar process of the meta-thoracic segment. Nevertheless the curved or angulated route ensures that it shall be of considerable length, longer, that is, than a merely simple transverse course across the back of the larva.

I succeeded in seeing this cable or girth manufactured on several occasions, but that does not seem to help me in describing it in words. As in *Papilionidæ* and *Pieridæ*, it is not spun where we see it when completed, but in a

position that may be described as in front of the larva, the head being thrown back, so that the legs are used as hands, one might say, to hold it up. Not, however, the claws, but the thick bases of the legs are used, the silk not being on the legs proper, but rather in the incision in front of them. This is the position when the spinneret is at the middle of the girth. But as the head goes from one side to another, the relations of parts is much changed, though quite gradually and automatically. It is this that makes it difficult to give a description easy to understand.

The actual line of the girth, at the middle of the movement, when the larva is straight with the head and legs well raised, is behind the marginal process of the 1st abdominal segment, then forwards above the marginal processes of 2nd and 3rd thoracic, and then across the larval venter to the other side in the incision between the first and second pair of legs. I have said the head is well raised, and so it is, by the Sphinx attitude of the first segments, but it is strongly bent forwards, so that the tip of the spinneret reaches very closely to the position of the girth in the incision behind the first pair of legs. I say very nearly, for the girth when completed consists of a number of quite separate threads, showing that each thread is *not* spun along, and glued to those that preceded it, and that therefore the extremity of the spinneret does not actually reach and touch the previously spun threads, which lie deeper in the incision between the segments.

As the larva moves its head from side to side in adding each thread, the position of the girth differs from this central position by being stretched along one side and all but relieved from the other; when the head is round to the left and the left end of the thread is being fixed, the thoracic and first two abdominal segments have their right sides stretched so as to form the margin of nearly a circle, whilst their left sides are so approximated as to be close together at the centre of the circle. In this attitude the line occupied by the girth above the marginal tubercles on the stretched side of the larva is raised above the surface on which the larva rests, and is on what for the moment is rather the upper-side of the larva, though it would be rather the under-side if the larva were in a natural resting attitude, since, as I have above called attention to, the larval warts are, and look, higher up on the larva than their real anatomical positions would indicate.

The following notes made whilst actually watching the larva may help to explain the spinning of the girth, though they have some incoherence from the circumstances of their production.

Cassandra, when building its loop, has it quite ventral, it passes round above the marginal wart of 2nd and 3rd thoracic and 1st abdominal and between the 1st and 2nd pairs of legs. There is, however, only one phase in this process to which this applies, viz. when a thread of silk is being added to the loop at exactly its highest point. When the spinneret is against either side of the loop or working at the point of attachment, the loop is free from all contact with that side of the larva, or just touches the marginal wart of 1st abdominal, whilst it is fully stretched on the other side, over the 2nd thoracic leg, the three warts (2nd, 3rd thoracic, 1st abdominal), and touches the ventral prominence of 1st abdominal. The attitude of the larva being that of a curve or twist that brings these parts directly away from the twig of attachment, whilst those that the loop is free from are crowded together towards the twig, the three warts having their apices close together, and so that on the curvature relaxing they expand again into that side of the loop and hold it whilst the other side contracts and frees itself from the loop in its turn.

The larva moves very leisurely, and with some to and fro movement, so that one traverse of the loop takes about three minutes and the movements of fastening the end of each thread to the twig about one minute; but between each complete traverse usually at least one partial journey is taken, *i. e.* from the twig for about one-third of its length and then back again, and along this piece especially towards the end of the process a good deal of local spinning is done which covers this thicker portion of the loop with an outside binding. When the loop is finished, the central third consists of a number of threads more or less separate, or at least apparently separate, straight, parallel and uncomplicated. The end portions are thicker, and bound together as one strong strand.

As the larva moves its head from side to side, the loop slips to and fro, or rather perhaps the larva slips to and fro on it, the loop always taking the position described on the convex side of the larva, and lifting out of it on the concave, as the warts and legs are contracted together into

one eminence. The head and prothorax are stretched out when the attachment of the loop is being worked at, the first pair of legs being one on each side of the strand; when the centre of the loop is under the spinneret the thorax is bent back from the twig, but the head is bent down to bring the spinneret against the loop in front of the 2nd legs, and the 1st pair of legs become practically invisible. In two specimens watched the whole process took about an hour and a half, in a room at about 64°. One wondered all the time how the loop when finished was to get back to its place. This however is managed very simply and very quickly. After finishing, as it had appeared to finish several times before, one of the lappings of the side of the loop with binding threads, instead of sliding slowly round and bending the head down slowly as it went, to the position it takes when at the central point, it gave it this position at once, *i. e.* before moving round, so that the head went under the loop somewhat to one side, and as it then gradually assumed the median position, the thread lay across the middle of the front of the head. At the same time, however, as it assumed the median position, it bent back the head and curved the thoracic segments backwards, so as to bring close together the back of the head and the dorsal thoracic humps. Then the thread became slack over the head, and slipped back into its place. In one instance, the thread caught, on the side on which the manœuvre was made, the tops of the subspiracular warts of the meso- and meta-thorax, bending them back, the larva rested here a little, probably from some inadvertent movement of mine that alarmed it, and then by a simple turning and stretching movement the loop fell into its place. One asks, Why does the loop always fall to this identical spot, how does the larva manage to make the necessary movement so exactly? This question is justifiable as an expression of admiration that the larva should always make precisely the same movement, but is foolish in not seeing that the same movement will always produce the same result. In fact a little, but very little, latitude is possible, as one could see that the result would be the same had the movement been a little more or less ample, etc. Nevertheless, the length of the loop and the place from which it starts must be very exactly related to the length, thickness, and movements of each larva.

Another point may be noted, whilst the larva is at work

on the loop, the thoracic segments are rather contracted and the abdominal somewhat full, and when first the loop falls into place, it runs more directly backwards than it does later; the head of the larva being rather in front of the points of attachment of the loop. But gradually the abdominal segments shrink, the thoracic enlarge and bend forwards, the whole larva thickens and shortens so that the loop has the position described in my first note. The amount of spinning for the anal hold varies a good deal, but in two specimens in which it appears to be well elaborated, it stands up as a somewhat flocculent little mass, and the prolegs take hold not of this, but a little way in front of it, suggesting that the pupa shall have a freer access to it than if the prolegs held it

My special object being to see how the girth, now of course clearly seen and proved to be a girth, as in other *Papilionidæ*, got moved to the position and function of a nose-cable, I watched carefully for the moult to pupa, to see how this occurred. My notes on this throw no light on the critical question, but may be worth giving on their own merits.

A larva that was very close to the change was watched on—

May 26, 9 a.m. No very definite change noticeable. 10 a.m. Some movements observable and a slight change of colour. 10.30 a.m. All the red has gone from the warts, except those of 8 and 9 abdominal. The others are shrivelled and show no colour, except their black points, the rest of the larva is slaty-grey, quite different to what it was an hour or two ago. No trachea drawn out yet, 3rd thoracic and 1st and 2nd abdominal are very narrow and shrunk. 2nd thoracic large. A good many little wrinklings of empty skin are visible round warts as well as elsewhere on segments. Girth hangs heavily on marginal wart of 3, pressing it forwards, that of 1st abdominal seems to have slipped behind it on one side, collapsed against that of 3rd thoracic on the other. Wart of 9 still full and red, the red would almost seem to depend on the contained fluid, as it disappears with the shrinking and collapse of the warts, which has just occurred. The fluid which filled them must have been absorbed or evaporated very rapidly. Disturbed the larva by placing it in a better position for observation. 10.40. A few slight movements. 4th, 5th and 6th abdominal seem large as also 7th and 8th; 3rd

about normal, intermediate between these and the shrunk 1st and 2nd.

10.45. A few more movements, the changes of dimensions of segments have placed the mouth parts and the legs below the girth. They were not very definitely above or below it before, but rather unrelated to it, but a strictly lateral view made it cross over 2nd pair of legs.

11.35. Colour all but gone from warts of 9th abdominal and claspers are almost collapsed, no other very obvious change. Th. 64° Fahr. 11.50. Some movement occurring. The large size of abdominal 4th, 5th, 6th and 7th very conspicuous, the incisions being much expanded. The appearance is as though the girth was holding up the skin on 1st and 2nd abdominal and meta-thorax, but the contents had gravitated back and distended these lower segments. In this specimen the silk for the tail grip is a little tag, a little loose and flocculent, shaped like a short blunt thorn, of which the apex is at present opposite the middle of the dorsal surface of 10th, the prolegs holding the stem to which the larva is attached some 2·5 mm. above it.

12.30 p.m. Length of different portions of larva: Head and 1st and 2nd thoracic = 3 mm., but these are curved and are much more along dorsum. 3rd thoracic, 1st abdominal = 2 mm., *i. e.* 1 mm. each. 2nd and 3rd = 3 mm. = 1·5 each. 4th, 5th, 6th = 7 mm., *i. e.* 2·3 mm. each; 7th, nearly as much. 7th, 8th, 9th, 10th = 5 mm.

12.45 p.m. Strong movements of contraction in 2nd, 3rd, 4th abdominal segments, but quiescence elsewhere. No definite vermicular movements.

12.55. Regular vermiform movement from behind forwards, one every five seconds without so far much change in skin.

12.58. Tracheæ drawn out along abdominal segments 2–7, loop drawn back, front segments straight.

1.2 p.m. Split down back in usual way. Skin slips back under loop.

1.5. Skin behind loop. Scrap of broken-off tubercle sticks to it; loop lies in 3rd and 4th abdominal incisions.

1.10. Skin gone. The movements of getting hold by the cremaster move the loop to the thoracic abdominal incisions, where it deeply indents wings during movements

for getting rid of skin. Wings not yet descended fully on to 4th abdominal.

1.15. Various movements apparently for forcing fluid forward and expanding wings, etc.

1.18. The attachment of the loop is just opposite the eyes of the pupa; wings, etc., and head above loop swollen and knobbed, below smooth and tapered.

1.22. Occasional movements, but on the whole resting, wings not quite down. Hangs much like an ordinary *Papilio*, except for apparent strangulation of front.

1.24. Wings to place.

1.35. 1st spiracular hollow (with black spiracle at bottom) sinking, dorsal eminence of meso-thorax and wing angles becoming of more mature form and less like swellings from strangulation, but loop still cuts deeply into wing and across base of hind-wing.

1.50. The wings are much straightened out and the loop cuts into them very little to what it did. Abdominal segments are shortening and closing up, not yet quite so much as in a mature pupa.

1.54. Is hanging with a strong sag (or bend) in abdomen.

2.3. From head to end of 4th abdominal, now very long and abdominal segments diminished. The loop is now hardly buried and is seen to be on top of 3rd thoracic (not in 3rd thoracic to 1st abdominal incision) at about $\frac{1}{5}$ or $\frac{1}{6}$ of its width from front border.

2.15. Straightened itself a little and then fell back again. Meso-thoracic dorsal ridges becoming sharper, anterior end still obviously somewhat soft.

2.25. Straighter,—no deformity of wings can be seen either where loop now crosses, or where it did before, except it seems a little impressed on one ridge of the venation.

2.30. A lateral jerk or two.

3.40. Loop is still a girth, though pupa is apparently mature as to form, and much dark shading has appeared.

5.45. No further change, still slung as a *Papilio*.

In both this and following specimens the girth is quite loose and at liberty to slip in any direction. Moving the pupa by touching the head enough to show the girth to be quite free does not in any way alter its position.

It does not look possible for it to slip forwards, but a twist of the pupa might catch it by the wing-spine and

throw it forward. Something of this sort must occur,—when ?

May 27. This specimen escaped observation but moved the girth to nose-hooks some time between 1.15 and 3 p.m., twenty-four hours after moulting to pupa.

Second Specimen.—May 26, 12.35 p.m. Subspiracular tubercles of 1st, 2nd, 3rd and 4th abdominal are now colourless and collapsed, dorsal and marginal of same region also changing. 3rd and 4th abdominal segments are beginning to enlarge. Incisions 4th to 5th abdominal getting wide; up till half-an-hour ago no change was visible and segments were not of very unequal lengths.

1.16. Only a few anal warts still coloured.

1.35. Only wart of 9th abdominal segment still coloured red.

1.50. Thermometer 74° Fahr. Abdominal segments large and incisions wide, 3rd thoracic and 1st abdominal very small. The higher temperature seems helping this specimen on more rapidly than No. 1.

2 p.m. Abdominal incisions wide, lower end looks like end of pupa with larva skin overlaid and claspers (shrunk) stuck on outside.

2.20. 4th, 5th and 6th abdominal very large, incisions wide ; some stretching, almost vermiform, movements.

2.43. Genuine rhythmical vermiform motion begins and head rises a little.

2.50. Quiet again, the three free incisions (of pupa) very wide; from abdominal 4th to 5th incision to head, 11 mm., to claspers, 9 mm.

2.59. Movement beginning again, in 1st, 2nd and 3rd abdominal segments.

3.5. Regular vermiform movement from end to end.

3.6. Skin accumulated at tail.

3.7. Thoracic skin split, it slips down, the collapsed warts passing under loop.

3.15. Process finished. The getting rid of larval skin is delayed a little by its fluid adhesion to pupa. The cremaster got hold at second try, and skin was shoved off at two twists, after fluid adhesion gave in. Loop fell into abdominal 3rd–4th incision as soon as skin left it, but in twistings for shoving off skin it slipped quickly to back of prothorax. To end of wings 8 mm., wings to cremaster, 12 mm.

3.22. Wings getting rapidly down to place. There are

contracting and expanding (lengthwise) movements of thorax.

3.30. Wings into place. 9 mm. head to end of wings, 11 mm. wings to cremaster = 20 mm.

3.40. Top of wings and meso-thorax, etc., have the appearance of being strangulated above loop, being swollen out and lumpy.

3.45. On lateral view, pupa has very *Papilio*-like outline, say *podalirius*, head thrown back, curvature with ventral projection of wings, etc., very different from the straightness of the mature *Thais* pupa.

4.3. Is now hanging very much sagged and bent.

5.45. Seems nearly mature and has more dark colouring. Head to end of wings 12 mm. Wings to cremaster 9·5.

May 27, 4.50. Was not looking at specimen but at another two inches from it, when a sudden movement attracted my attention to it.

I was in time to see the girth take hold of the nose-spines, and see the pupa complete what appeared to be two revolutions on its axis, but might have been one, or three; the whole taking place in less than a second, perhaps a third of a second, apparently as rapidly as an active pupa rotates his tail.

A very unexpected movement, as the pupa looked so straight and stiff (and it is fairly stiff when one receives it in autumn), and for a pupa with a girth to rotate on its axis seems so unlikely, the way in which the girth is twisted round the nose-hooks led me to expect a rotatory movement, but without any change of orientation. What struck me afterwards as remarkable was how in such a sudden movement the pupa came to rest again exactly facing its attachment. An examination of these two pupæ shows that they made at least two revolutions, as the girth has reached the nose-hook and one further revolution has been made twisting it round once (quite) after it had caught, and the cremastral silk also shows twisting.

I have not made it very clear how the revolution is effected. It is by bending the tail to one side and then twirling it round; when I say to one side, I should in this case say forwards, as the attitude during the movement was that of bending away from the supporting twig.

Another specimen was observed to make a second rotatory movement, on one occasion, some hours after the cable had been moved forwards, but it would seem to be

the rule that rotation is made once only for a fraction of a second, about twenty-four hours after the moult.

The rotation is on an axis, *i.e.* it does not sweep the head round in a circle, maintaining the venter towards the stem of attachment all the time, but presents towards the stem successively one side, the dorsum, the other side, and so on. The rotation is effected by the abdominal segments being bent forwards, *i.e.* virtually making the pupa present a deep curve towards the stem. Then by sweeping round the abdominal segments in a way that is common to many pupæ the hollow of the curve remains towards the stem, but affects successively each aspect of the pupa as it rotates.

The mature pupa a few days later is very stiff and straight, and its possessing such motility twenty-four hours after moulting is somewhat unexpected.

In order to observe the way in which the girth is made by the larva of *Papilio*, I obtained a few larva of *P. machaon*, and kept rather a close watch on them, but four succeeded in suspending themselves, girth and all, without my having surprised them at work. They do it apparently somewhat quickly, and give no clear indication beforehand of when they are likely to do so. With the fifth I was more fortunate, happening to look at it when the making of the girth was under way, indeed more than half-finished; he was working at one end, passing the spinneret too and fro about the attachment of the loop. The loop itself, consisting of a number of quite detached threads, passed between the fore-legs of the larva, forwards, the larva being so bent round that its head and prothorax were directed backwards. Then well above the meso-thoracic leg and rather higher on the meta-thorax, then well above the spiracle of the 1st abdominal, not quite so far above that of the second, and then passed down to its other attachment. The most anterior portion of the larva in this position was the side of the meta-thorax and 1st abdominal segment just below the loop. Then the larva began to add another thread to the loop. The head and front segments are well raised and the loop falls into the incision between the 1st and 2nd pair of legs, the head is pressed down and the spinneret lies between the first two legs and reaches very close to the loop; the larva sweeps the head across from the one end of the loop to the other slowly and by short jerks and stops, as though the silk

had to be drawn out. As it does so, the loop which was stretched over the sides of the four segments (2nd, 3rd thoracic, 1st, 2nd abdominal) on one flank, gradually leaves them and becomes stretched over the same line on the opposite side. Then the process of fastening it and spinning various sinuations of silk over the other place of attachment of the loop is repeated. I saw it do this several times, and then at one end it delayed a little, and came up with the head not above the loop, still less the front-legs, but with the loop across the front of the head at the base of the labrum. When about the middle, it made some movements and I thought it was going to throw the loop backwards into place; this, however, it did not do, but continued to the other side; so far as I could see it spun no thread this time, it then twice repeated the ordinary process of adding a thread, and again repeated the passage with the thread above the labrum. It was now making a good many contortions with the effect that the anterior segments became decidedly diminished in bulk; as soon as it reached the end of the loop with it above the labrum, it put the head with little difficulty under the loop so that the loop was across the vertex, and then making the passage across and raising the mouth end of the head, the loop easily slipped backwards. It was not, however, before some little time spent in twistings and contortions, that looked as if intended to push the loop back, but were really effective in again distending the front part of the larva and diminishing the posterior that the loop fell into its place between the 2nd and 3rd abdominal segments, and the larva rested as quite satisfied.

Though the larva was slow and deliberate in its movements this was all done in a very few minutes; the threads of the girth seem to remain distinct and separate, and do so to much nearer their attachment than in *T. cassandra*, where the spreading of silk over the attachment includes the lapping of the adjacent portion of the loop.

It may be noted that the position of the loop in the larva between the 2nd and 3rd abdominal is constant, as I saw it in all specimens, though I did not see it made. In the pupa it is different, viz. just behind the middle of the meta-thorax.

It sinks into the soft chitin of the newly-moulted pupa which, as it were, flows over it in two places on each side, there is in fact a lappet formed at each of these places,

that passes over the loop and encloses it in a short tunnel. Sometimes it is quite fixed here, at others it can be drawn through these tunnels and removed, if it is first cut. The two places where these lappets are found are on the hind-wing, and on the fore-wing just below the cell some little way basal to vein 2.

It is perhaps erroneous to say that the loop sinks into the soft chitin, at least to say so may produce the false impression that there is something accidental about it; it is, however, a constant arrangement, and the lappets are no doubt structures specially arranged for the purpose.

To test this a larva suspended for pupation was treated by cutting the loop away. It was seen very shortly after pupation, before the pupa had quite assumed its permanent form and was still very soft. The very striking fact appeared now, that across the wings there was a very distinct depression marked by a central linear mark, as if the girth were present and indenting the soft pupa. When the pupa had attained maturity with a firm skin, this appearance had gone, and at first glance there was no evidence of the overlapping chitin that bridges over the girth. A closer look, however, showed the prominence at the base of the under-wing that forms the anterior overlapping margin, with a linear groove just behind it, and on the middle of the fore-wing at the position of the tunnel for the girth is a glazed line, but no definite overlapping. It therefore seems that the pupa is prepared for the girth taking its proper position by a definite channel occurring across the wings whilst the cuticle is still plastic; that the two special places (on fore- and hind-wing) are prepared for its inclusion beneath the surface; that of the hind-wing which is a very strong lappet forms even if the girth is not there; that on the fore-wing, the overlying lappet does not form, unless it has the assistance of the downward growth of the wings, which occurs during the maturing of the pupa just before hardening, and as the lappet is not formed, the walls of the tunnel that would contain the girth are left exposed as a glazed line in this position.

As a subsidiary effect of cutting the girth the pupa did not succeed in fastening the cremaster on the provided anal pad of silk. When at rest for pupation the claspers hold the silk in front of the pad, which stands up unoccupied just behind the pupa, or rather behind the claspers and under the end of the anal plate, and in

moulting the cremaster is thrust back over the skin to reach the pad. The loss of the girth, however, deprives the pupa of the power of preserving a correct alignment, and so the fulcrum provided by the skin held in place by the claspers cannot be efficiently utilized.

The whole process of spinning the girth seems therefore to be identical in *Papilio* and *Thais*.

P.S.—The abortive journeys across the loop, between the spinnings of its separate threads and the final journey in which the loop is thrown back, may be speculated on as showing that the movement for spinning and that for throwing back are variations of one and the same movement, and that the definite distinction between them is not so fixed, but that an intermediate movement may occur, either as not being yet entirely eliminated or by reversion.

The larva of *rapæ* makes the girth in a way that is essentially the same as in *Papilio*, but yet with an amount of variation that renders it actually very different. Essentially the girth is made in front of the larva and between the head and first pair of legs (not between the 1st and 2nd pair of legs, as in *Papilio*), but the raising of the front segments of the larva, which in *Papilio* may be likened to the "Sphinx" attitude, is in *rapæ* carried to an extreme, so that when the larva is adding to the middle point of the girth the head is bent back so that the back of the head touches the dorsum of the abdomen, about the incision between 2nd and 3rd abdominal segments, the ventral face of head and first thoracic segment being directed exactly dorsal, the legs of 2nd and 3rd thoracic, forwards. As the head is carried to either side, these forward segments so rotate that the venter becomes ventral over all segments, but the forward segments instead of being bent dorsally, are bent laterally, and the head is against the side of the 2nd and 3rd abdominal segments. In all these positions the loop seems to be fairly tense. When the head is bent to one side, the girth passes over the middle of the 2nd abdominal segment and the middle of the 1st thoracic, the portion of the larva between these two positions being in front of the loop, the rest behind it. In the median position, there is perhaps a large proportion of the 1st thoracic segment in front of the loop. Indeed the head only might be regarded as behind the loop. It is observable, that during this process the

2nd abdominal segment seems small and contracted, the abdominal segments behind and the thoracic in front seeming relatively swollen.

The completion of the process, when the spinning is finished, is really very different from that in *Papilio*. In *Papilio* the front of the head is put forward under the loop and it is slipped back into its place by a movement very similar to that by which a thread is added to the girth. In *rapæ*, at the end of fixing the last thread at the side, the head is merely drawn forward from under the loop.

The references to the spinning of the loop in *Pieridæ* that I have met with, give the idea that it is spun from the outside across the abdominal segments, the spinneret being carried to and fro across the surface of the segment—a feat that a moment's reflection on the details of such a process will show to be impossible. It is made across the 2nd abdominal segment, but the larva is so bent back that the loop passes at the same time round its neck and the spinning is from the inner- or under-side.

When I say that the spinning from the outside is impossible, it is perhaps going too far, for there is no necessary limit to the amount of bending a larva may do, but when one sees the amount of strain on the full-fed larva of *rapæ* to get the head as far back as it does, it is seen that whatever it might be for some hypothetical larva, it would be impossible for *rapæ* to bend further back till the spinneret touches the abdominal dorsum. Or if we take the actual position when the larva is fastening one end of the loop, if it thence carried the spinneret up the side of the segment towards its dorsum, the combination of lateral bending and longitudinal twist would stop the process before the spinneret reached the dorsum, much less reached the other side.